# Coronary atherosclerosis distribution and the effect of blood glucose level on operative mortality/morbidity in diabetic patients undergoing coronary artery bypass grafting surgery: a single center experience

## *Koroner baypas operasyonu yapılan hastalarda kan şekeri düzeyinin ameliyat mortalite/morbidite üzerine etkisi ve diyabetik hastaların koroner ateroskleroz dağılımı; Tek merkezin deneyimi*

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## ABSTRACT

**Objective:** The study aim was to investigate the effect of blood glucose level on atherosclerotic lesion distribution and the contribution to the operative mortality/morbidity in diabetic patients who underwent coronary artery bypass grafting (CABG).

**Methods:** Between 1986-2003, a total of 2095 patients with diabetes mellitus underwent CABG. The analysis was carried out retrospectively from the clinical records. The patients were divided into four groups according to the blood glucose levels that were obtained when they first applied to hospital; Group 1 (492 patients with blood glucose < 120 mg/dl), group 2 (1112 patients with blood glucose - 120-200 mg/dl, group 3 (261 patients with blood glucose 201-250 mg/dl) and group 4 (230 patients with blood glucose > 250 mg/dl). "One way ANOVA" test was used for the statistical analysis of continuous variables and Chi-square test was used for analyzing the categorical variables.

**Results:** Emergent operation rate due to acute ischemia gradually increased from Group 1 to Group 4 and reached 6.6% in Group 4 ($p=0.005$). Operation time and the duration of cardiopulmonary bypass and cross clamp were significantly longer in patients with high blood glucose levels ($p<0.05$). Necessity for inotropic drug administration postoperatively ($p<0.05$) and mechanical support ($p<0.05$) were significantly higher also. The hospital mortality in group 3 was 9.6% and in group 4 was 11.3% ($p=0.09$). No statistically significant difference was found in terms of morbidity between the groups ($p>0.05$). The multi-vessel coronary artery disease was more common in groups with high blood glucose level ($p<0.05$). As the blood glucose level raised, patients were more frequently ($p<0.05$) confronted with distal left anterior descending artery, middle circumflex artery and right coronary artery lesions.

**Conclusion:** Uncontrolled blood glucose level not only increased the perioperative complications but also the incidence of middle and distal coronary artery lesions. It is necessary to diagnose and aggressively treat the high blood glucose level especially before the CABG. *(Anadolu Kardiyol Derg 2007; 7: 158-63)*

**Key words:** Coronary atherosclerosis, diabetes mellitus, coronary artery bypass surgery

## ÖZET

**Amaç:** Koroner baypas operasyonu planlanan hastalarda kan şekeri düzeyinin diyabetik hastalarda koroner aterosklerotik lezyon dağılımının araştırılması planlanmıştır.

**Yöntemler:** 1986-2003 yılları arasında koroner baypas yapılan diyabetes mellituslu 2095 hasta çalışmaya dahil edilmiştir. Araştırma retrospektif olarak hasta kayıtları üzerinden yapılmıştır. Hastalar, hastaneye ilk başvurdukları anda yapılan tetkiklerindeki kan glükoz seviyelerine göre 4 gruba ayrılmıştır; Grup 1 (492 hasta, kan glükoz seviyesi<120 mg/dl), grup 2 (1112 hasta, kan glükoz seviyesi 120-200 mg/dl), grup 3 (261 hasta, kan glükoz seviyesi 201-250 mg/dl), grup 4 (230 hasta, kan glükoz seviyesi >250 mg/dl). Devamlı değişkenler için "one way ANOVA", kategorik değişkenler için Ki-kare testi kullanılmıştır.

**Bulgular:** Akut iskemiye bağlı acil operasyon gruplar arasında birden dörde doğru giderek artmakta ve Grup 4'de % 6.6'ya ulaşmaktadır ($p=0.005$). Operasyon, kardiyopulmoner baypas ve kros-klemp süreleri kan glükoz seviyeleri yüksek olan hastalarda anlamlı derecede uzundur ($p<0.05$). Ameliyat sonrası inotropik medikasyon ($p<0.05$) veya intraaortik balon desteği ihtiyacı ($p<0.05$) kan şekeri yüksek olan gruplarda anlamlı olarak yüksek bulunmuştur. Hastane mortalitesi ise, Grup 3'de % 9.6 ve Grup 4'de 11.3 ($p=0.09$) olarak bulunmuştur. Morbidite açısından gruplar arasında fark bulunmamıştır ($p>0.05$). Yüksek kan şekerine sahip gruplarda çoklu damar hastalığı oranı daha yüksek bulunmuştur ($p<0.05$). Kan şekeri düzeyi yükseldikçe, hastalarda daha sık olarak distal sol ön inen , orta sirkumfleks ve sağ koroner arter lezyonları saptanmaktadır ($p<0.05$).

**Sonuç:** Kontrolsüz kan şekeri düzeyleri yalnızca perioperatif komplikasyonların görülme sıklığını arttırmakla kalmaz, aynı zamanda orta ve distal koroner arter lezyonlarının görülme insidansını da arttırır. Özellikle koroner baypas ameliyatlarından önce yüksek kan şekerinin tespit edilmesi ve agresif olarak tedavisi çok önemlidir. *(Anadolu Kardiyol Derg 2007; 7: 158-63)*

**Anahtar kelimeler:** Koroner ateroskleroz, diyabetes mellitus, koroner baypas cerrahisi

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## Introduction

Diabetes mellitus is a well-known risk factor in coronary artery disease (CAD) and atherosclerosis is responsible for 80% of deaths in diabetic patients. Two-thirds of these are related with coronary artery disease and one-third is related with cerebral or peripheral artery diseases (1). Severe CAD can be successfully treated with coronary artery bypass grafting (CABG) with a considerable improvement in terms of relief of angina pectoris. Diabetic patients have been shown to be at a higher risk of complications with a higher long-term mortality rate after CABG as compared with non-diabetic patients (2). It has been known that, the mortality rate after the operation in diabetic patients increases about 50-90% because of the accelerated atherosclerosis. Also, some other underlying pathologies may contribute to accelerated atherosclerosis in the diabetic patients. Hyperglycemia increases the tendency to infection and depresses wound healing process by interfering with the function of polymorphonuclear leucocytes and fibroblast proliferation (3, 4). Among these, increased platelet activity and an abnormal shifting to coagulation in the coagulation-fibrinolysis equation, adverse effects on lipid metabolism, and disorders of endothelial activity are some of the results of diabetes mellitus (DM). The higher mortality among diabetics after revascularization is also felt to be consistent with the anatomic aspect of the disease (diffuse distal CAD, small vessels, diffuse calcifications). Once myocardial infarction (MI) occurs in the diabetic patients, the rate of acute-late mortality and re-infarction is doubled (3-5).

In the perioperative and postoperative courses of coronary bypass operations, diabetic patients are often had a disadvantage compared with nondiabetic patients. We wish to search the effects of the regulation of blood glucose levels on mortality and morbidity in high-risk groups such as patients with coronary heart diseases. In this study, we also investigated the effect of diabetes mellitus on atherosclerotic lesions distribution according to diabetic control.

## Methods

Between 1986 and 2003, 2095 patients with diabetes mellitus underwent CABG in Türkiye Yüksek Ihtisas Hospital, Ankara, Turkey. The rate of the diabetic patients operated in our hospital was approximately 19.6%. The study group was divided into four groups according to their blood glucose levels that were obtained when they first applied to hospital. These groups were as follows; Group 1 (492 patients) with blood glucose < 120 mg/dl, Group 2 (1112 patients) with blood glucose - 120-200 mg/dl, Group 3 (261 patients) with blood glucose - 201-250 mg/dl and Group 4 (230 patients) with blood glucose - > 250 mg/dl. All patients Group 1 had been diagnosed as clinical DM before applying to our hospital but 69.4%, 56.7%, 67.8% of the Group 2, 3, 4 patients had been diagnosed after their application to our hospital. Prior diagnosed diabetic patients who applied to our hospital had been followed up in different endocrinology clinics for mean 6.5 years. The distribution of the treatment modalities of these patients was as follows; 18.2% received insulin, 42.5% - oral antidiabetic, 14.5% were regulated by diet, 24.8% were not regulated. Information was obtained retrospectively from the clinical records at the authors' institution. The demographic variables of the patients are shown in Tables 1 and 2.

Diabetes mellitus protocol of our institution: The patient is hospitalized minimum 2-days before surgery in order to optimize the blood glucose control. The patients using oral-antidiabetic drug, if their glycemic control is not effective, is treated with insulin. If the blood glucose level is <200 mg/dl in the operation morning, the patient is accepted to be appropriate for the surgery; if not, the operation is postponed. Glucose-insulin-potassium (GIK) infusion is administered 3-hours before the surgery. The glycemic control during the operation is accomplished by insulin infusion that is adjusted according to the patients' blood glucose level, which is controlled every hour. We followed-up the Portland Protocol postoperatively during the last 3 years (6).

**Table 1. Demographic and preoperative variables according to blood glucose levels**

| Variables | Group 1 | Group 2 | Group 3 | Group 4 | p* |
|---|---|---|---|---|---|
| Gender (woman), % | 26.4 | 22.8 | 33.0 | 32.6 | 0.001 |
| Age, years | 57.9±9.1 | 57.1±9.1 | 57.4±9.6 | 56.2±8.8 | 0.1 |
| Blood glucose level, mg/dl | 100.9±14.4 | 158.1±21.5 | 221.8±14.4 | 304.4±61.3 | 0.001 |
| Family history, % | 26.0 | 20.8 | 21.8 | 20.4 | 0.1 |
| Smoking, % | 33.7 | 35.9 | 31.0 | 28.3 | 0.1 |
| Hypertension, % | 47.8 | 40.7 | 35.6 | 38.3 | 0.005 |
| Obesity, % | 11.2 | 10.2 | 11.1 | 10.9 | 0.9 |
| Hyperlipidemia, % | 12.2 | 12.8 | 12.3 | 17.8 | 0.1 |
| Stable angina pectoris, % | 62.2 | 62.1 | 61.7 | 63.5 | 0.9 |
| Unstable angina pectoris, % | 25.6 | 25.6 | 21.8 | 19.6 | 0.1 |
| Peripheral vascular disease, % | 1.4 | 1.7 | 1.1 | 0.9 | 0.7 |
| Urea> 50 mg/dl | 14.8 | 15.0 | 16.3 | 18.0 | 0.6 |
| Creatinine> 1.2 mg/dl | 13.2 | 17.4 | 18.5 | 12.6 | 0.08 |
| Triglyceride, mg/dl | 147.8±113.2 | 157.9±117.6 | 161.1±137.7 | 162.1±150.9 | 0.3 |
| Cholesterol, mg/dl | 170.1±78.5 | 167.7±91.2 | 164.4±107.7 | 157.2±104.4 | 0.3 |

*- ANOVA analysis

The preoperative risk factors of the patients (family story, smoking, hypertension (blood pressure>140/90 mmHg (7)), obesity (body mass index>30 kg/m$^2$(8)), hyperlipidemia (LDL cholesterol>130 mg/dl (9) etc.), angina type (stable angina pectoris, unstable angina pectoris), presence of peripheral vascular disease, presence of multivessel coronary lesion and left main coronary artery lesion, the rate of endarterectomy applied to coronary arteries, biochemical analysis of blood samples (cholesterol, triglyceride, urea, creatinine levels), mechanical complications that occurred because of MI (ventricular septal defect, left ventricular aneurysm, mitral incompetence), emergency status of the operation (urgent, elective), the duration of the operation, cross-clamp and cardiopulmonary bypass periods, postoperative cardiac rhythm and the rate of low cardiac output syndrome, the presence of acute hypertensive periods and pulmonary hypertension in the intensive care unit follow-up, preoperative and postoperative inotropic drug requirement and postoperative morbidity (postoperative MI in the ICU, neurological complications (major or minor cerebrovascular events), infection and hospital 30-day mortality were investigated in our study. The coronary atherosclerosis analysis was made by a researcher who was blind for the groups knowledge.

The coronary angiographies were evaluated and the lesion distributions in the coronary arteries were taken into consideration and noted down. The coronary lesions that were < 50%, were not included in the statistical analysis. The cardiopulmonary bypass, cross-clamp, operation and hospitalization periods were also investigated.

## Surgical Intervention

The CABG was performed with standard cardiopulmonary bypass technique and using cross-clamp. Myocardial protection was established by hypothermia (28-30 °C), topical cooling and initial cold crystalloid cardioplegia followed by blood cardioplegia solution (Plegisol-ABBOT©) were applied in 20-minute intervals. The cardioplegia solution was given antegradely from the aortic root through the cannula. Besides, retrograde cardioplegia was also given to patients. In addition to these, the last dose of cardioplegia was given as warm blood cardioplegia. A moderate degree of hypothermia and hemodilution was used. Postoperative inotropic drug administration included dopamine, dobutamine or adrenaline and vasodilator drug administration included nitroglycerine. Preoperatively intraaortic balloon pump (IABP) was placed to the hemodynamically unstable patients and the patients who were operated urgently.

**Table 2. Operative and postoperative variables according to blood glucose levels**

| Variables | Group 1 | Group 2 | Group 3 | Group 4 | p* |
|---|---|---|---|---|---|
| Preoperative IABP, % | 0.6 | 0.6 | 2.3 | 0.4 | 0.04 |
| Preoperative inotropic support, % | - | 0.5 | - | 0.4 | 0.2 |
| Emergency operation, % | 0.9 | 2.8 | 4.2 | 6.6 | 0.005 |
| Mechanical complications of CAD, % | 2.0 | 2.7 | 3.8 | 4.3 | 0.0001 |
| One-vessel disease, % | 24.0 | 20.3 | 18.0 | 12.2 | 0.002 |
| Endarterectomy, % | 1.4 | 2.2 | 2.7 | 3.5 | 0.3 |
| Operation time, minutes | 226.9±58.7 | 232.3±63.9 | 234.9±67.1 | 246.6±70.3 | 0.002 |
| CPB time, minutes | 68.6±31.5 | 71.5±33.8 | 75.9±37.9 | 76.1±37.3 | 0.01 |
| ACC time, minutes | 40.2±18.7 | 41.0±19.5 | 43.6±25.3 | 44.7±24.2 | 0.02 |
| Inotropic support use after operation, % | 12.0 | 10.3 | 17.6 | 20.4 | 0.0001 |
| Vasodilator necessity after operation, % | 14.6 | 13.8 | 16.9 | 18.3 | 0.2 |
| IABP need after operation, % | 2.8 | 2.9 | 5.0 | 7.0 | 0.01 |
| Postop rhythm (NSR), % | 96.0 | 97.5 | 94.7 | 93.7 | 0.03 |
| LCO, % | 5.9 | 5.8 | 7.3 | 7.8 | 0.5 |
| Acute HT in ICU, % | 18.9 | 15.8 | 16.9 | 16.1 | 0.4 |
| Acute PHT in ICU, % | 2.2 | 3.4 | 4.6 | 3.0 | 0.3 |
| Rhythm in ICU (NSR) , % | 96.0 | 96.3 | 92.6 | 94.0 | 0.05 |
| ICU Complications, % | | | | | |
| MI | 0.2 | 0.3 | 0.4 | 0.9 | 0.3 |
| Neurological | 1.0 | 0.5 | 1.9 | 0.9 | - |
| Infection | 0.6 | 0.08 | - | - | - |
| Hospitalization, days | 8.1±9.1 | 8.7±9.0 | 9.4±13.1 | 9.7±16.2 | 0.1 |
| Mortality, % | 6.9 | 7.1 | 9.6 | 11.3 | 0.09 |

*- ANOVA analysis

ACC- aortic cross-clamp, CAD- coronary artery disease, CPB- cardiopulmonary bypass, HT- hypertension, IABP- intraaortic balloon pump, ICU- intensive care unit, LCO - low cardiac output syndrome, NSR - normal sinus rhythm, PHT- pulmonary hypertension

Left internal thoracic artery (LITA) and saphenous vein grafts were mostly preferred in the operations. We have used mean 2.1 grafts / patient in this study (Table 3).

**Statistical Analysis**

Tests for normality of distribution analysis were carried out and the findings fit the normal distribution. One way ANOVA test was used for statistical comparison of continuous variables between the groups. Chi-square test was used for comparison of categorical variables between the groups. All values were reported as mean±SD. A p-value <0.05 was considered statistically significant.

## Results

There was no statistically significant difference in terms of age between the groups but there were more female patients in Groups 3 and 4 although men were dominant in all groups (p<0.05) (Table 1). Regarding the preoperative risk factors, hypertension was more prevalent in Group 1 and 2 (p<0.05). Family history, obesity, type of angina pectoris, presence of peripheral vascular disease, cholesterol and triglyceride levels did not differ among the groups. Levels of urea and creatinine tended to be higher in the uncontrolled glucose groups but the difference did not reach a statistical significance (p>0.05) (Table 1).

**Table 3. The grafts used in the operation**

| Variables | Group 1 | Group 2 | Group 3 | Group 4 | Total, n |
|---|---|---|---|---|---|
| LITA, n | 462 | 1011 | 219 | 201 | 1903 |
| RITA, n | 3 | 15 | 3 | 5 | 26 |
| SVG, n | 551 | 1359 | 339 | 316 | 2565 |
| Radial artery, n | 7 | 4 | 3 | 1 | 15 |
| Total, n | 1023 | 2389 | 575 | 523 | 4509 |

LITA- left internal thoracic artery, RITA- right internal thoracic artery
SVG- saphenous vein graft

**Table 4. Causes of early-mortality***

| Variables | Group 1 | Group 2 | Group 3 | Group 4 |
|---|---|---|---|---|
| Low cardiac output, n(%) | 22 (64.7) | 59 (74.7) | 18 (72.0) | 19 ( 73.1) |
| Cerebrovascular event, n(%) | 3 (8.8) | 5 (6.3) | 2 (8.0) | 3 ( 11.5) |
| Infection, n(%) | 3 (8.8 ) | 4 (5.1) | 1 (4.0) | 1 (3.8) |
| Acute renal insufficiency, n(%) | 1 (2.9) | 1 (1.3) | 1 (4.0) | 0.0 |
| Respiratory insufficiency, n(%) | 5 (14.7) | 10 (12.7) | 3 (12.0) | 3 ( 11.5) |

* Differences between groups are nonsignificant (p>0.05)

**Table 5. Causes of early-morbidity***

| Variables | Group 1 | Group 2 | Group 3 | Group 4 |
|---|---|---|---|---|
| Major cerebrovascular event, % | 0.6 | 0.6 | 0.4 | 0.4 |
| Minor cerebrovascular event, % | 0.4 | 0.08 | 0.8 | 0.9 |
| Mediastinitis, % | 1.2 | 0.2 | 0 | 0.4 |
| Rhythm problems, % | 0.6 | 0.4 | 0.4 | 0.5 |
| Postoperative MI, % | 0.2 | 0.3 | 0.4 | 0.9 |
| Postoperative bleeding, % | 0.2 | 0.7 | 0.7 | 0.0 |

MI- myocardial infarction
*Differences between groups are nonsignificant (p>0.05)

Preoperative management of IABP was significantly high in Group 3 (p<0.05) (Table 2). Regarding the emergency status of the operation, the rate of urgency due to acute ischemia gradually increased from Group 1 to 4 and reached 6.6% in Group 4 (p=0.005). The mechanical complications of MI such as post MI ventricular septal defect, left ventricular aneurysm and mitral insufficiency were encountered mostly in the groups with high blood glucose levels (p=0.0001) (Table 2).

Postoperative inotropic drug requirement (12.4% to 20.4%; p<0.0001) and necessity for mechanical support with IABP (2.8% to 7.0%; p<0.01) were significantly higher in patients with higher blood glucose levels. Sinus rhythm was achieved relatively rare in Group 4 when compared to Group 1 postoperatively (p<0.05). Low cardiac output was diagnosed in Group 3 and 4 more frequently than in Group 1 and 2 but this difference did not reach a statistical significance (p>0.05). Regarding the intensive care unit complications (MI, neurological complications and infection), no difference was observed among the four groups. Hospital mortality rate tended to be higher in high blood glucose level groups but we could not find a statistical significance (p=0.09). The hospital mortality in Group 3 was calculated as 9.6% and in Group 4 as 11.3%. The causes of early mortality after the operation were similar among the groups (Table 4). Of the factors that reflect the difficulty of the operation, the duration of the operation, cardiopulmonary bypass and cross-clamp were significantly longer in high blood glucose groups (p<0.05) (Table 5). Regarding the reasons of early morbidity, we did not find a statistical difference between the groups (p>0.05) (Table 5). Hospitalization period was shorter in low blood glucose level groups but this difference was not statistically significant (p>0.05) (Table 2).

The multi-vessel coronary artery disease rate was significantly higher in groups of high blood glucose level (p<0.05) (Table 2). We found some noteworthy differences between the groups in terms of anatomic atherosclerotic distributions of the lesions in the coronary arteries. Distal left anterior descending coronary artery lesions were recognized in 1.5% and 2.2% of the patients in Groups 3 and 4 (p<0.05). Middle circumflex and right coronary artery lesions were diagnosed significantly higher in high blood glucose level groups. Optional diagonal coronary artery lesion was higher in Group 3 than in the other groups. Atherosclerotic lesion distributions in the coronary arteries are shown in Figures 1a, 1b, 2a, 2b.

## Discussion

Diabetes mellitus is a well-defined risk factor in the formation of CAD and places a huge burden on health care resources because of the accelerated rate of CAD (10). Coronary artery diseases incidence is found to be 55% in diabetic patients, while it occurs in 4% of non-diabetic individuals (11). The incidence of all manifestations of CAD (MI, angina pectoris and sudden death) is greatly increased in diabetic patients. On the other hand, the rate of the diabetics is increasing in the patients who underwent CABG. In recent studies, the ratio of diabetes mellitus is claimed to be 11 - 27%, which is close to the rate in our study -19.6% (12).

The anatomical distribution of the lesions may also differ in the diabetic patients. In an extensive autopsy study, 91% of the diabetic patients had a lesion at least in one of the coronary arteries, and 83% of the patients had two or three-vessel CAD (13, 14). In our study, the multi-vessel coronary artery disease was found to be more prevalent in groups of high blood glucose level, which

is in agreement with literature data. The one-vessel disease rate was 24% in Group 1, but it was 12.2% in Group 4. The coronary artery lesions were diffuse, distal and coronary arteries tend to be small outflow vessels with serious calcifications. Although it was not statistically significant, the coronary endarterectomy rate was 2.5 times higher in Group 4 compared with Group 1 in our study. Diabetes mellitus and blood glucose level alter the atherosclerotic lesion distribution, and usually mid and distal segments of the arteries are affected. In our study, the distal segment of left anterior descending artery, mid-segments of circumflex and right coronary artery were affected more in patients with high blood glucose levels at the time of application to our hospital than the patients who had low glucose levels.

The rate of mortality and morbidity has generally been accepted to be high in diabetic patients who underwent CABG and varies between 1.8 - 9% (15). Among several reasons such as neurological, respiratory and infectious, CAD is the most frequent one that causes mortality in diabetic patients. The contribution of dehydration and electrolyte imbalance related to hyperglycemia is important. After surgical procedures, the increase in the level of free fatty acids might depress heart functions, increase the myocardial oxygen demand and has an arrhythmogenic potential (16). In the CABRI study, which investigated both diabetic and non-diabetic patients, it has been found out that the mortality rate of the diabetic group was twice as much higher than in the non-diabetic group. In the wide retrospective series, according to the multivariate analysis, DM had been found to be an independent risk factor for mortality (17, 18). As Adler and Morris said, Thourani et al, also stressed the negative effect of DM on the hospital mortality and furthermore, emphasized the role of DM in the long-term mortality rates as well (3). In our study, hospital mortality was found to gradually increase from the Group 1 to 4 and reached 11.3% in Group 4. Emergent operations rate with acute ischemia was also significantly higher in Groups 3 and 4 when compared with Groups 1 and 2. Additionally, the mechanical complications of MI such as post MI ventricular septal defect, left ventricular aneurysm and mitral incompetence were also encountered mostly in the groups with high blood glucose levels as 2% in Group 1 and 4.3% in Group 4.

The important factors that increase the risk of CAD in diabetic patients are high cholesterol levels, hypertension, smoking and unregulated blood glucose levels. Seventy-five percent of the adult diabetic patients are obese and obesity is related with all the other risk factors independently. We found the triglyceride levels slightly higher in high glucose levels without any significance. We could not found a statistical significance in terms of cholesterol levels, the lipid parameters and the rate of obesity among the groups. Thourani et al. (3) compared diabetic patients with the non-diabetic ones and found that the incidence of female gender, hypertension, MI, congestive heart failure were higher in diabetic group and also diabetics were found to be older and their angina was more serious. Additionally, the incidence of low ejection fraction, triple-vessel and left main coronary artery disease were higher in diabetic patients (3). In a study reported by Szabo et al. (1) that had included 2779 patients who had undergone CABG, 19.4% of the patients were found to have diabetes mellitus, and in the diabetic group younger age and the incidence of unstable angina pectoris, three-vessel disease and the ratio of women gender were found to be higher. Furthermore, they also found out that the diabetic group's duration of cross-clamp and

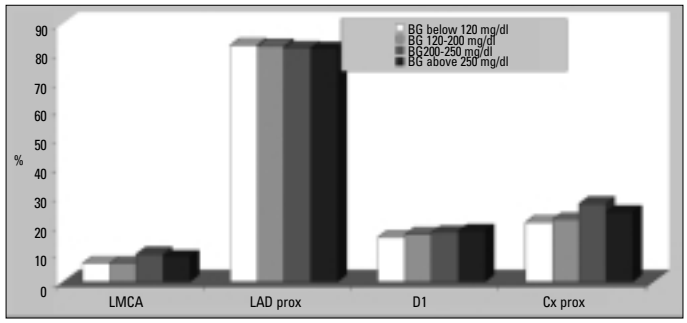


**Figure 1a. Atherosclerotic lesion distribution of left main coronary artery (LMCA), proximal left anterior descending artery (LAD prox), first diagonal artery (D) and proximal circumflex artery (Cx prox) between groups**

BG- blood glucose level

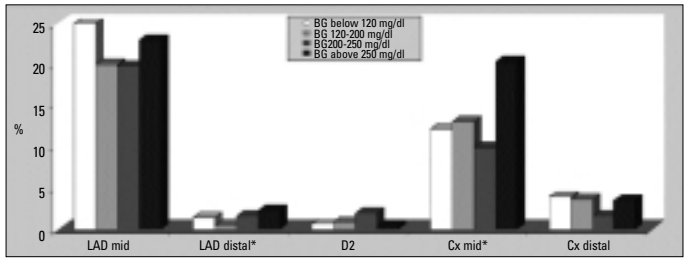


**Figure 1b. Atherosclerotic lesion distribution of middle portion of left anterior descending artery (LAD mid), distal portion of left anterior descending artery (LAD distal), second diagonal artery (D2), middle portion of circumflex artery (Cx mid), distal portion of circumflex artery (Cx distal) according to groups (*- p<0.05, for differences between groups by ANOVA analysis)**

BG- blood glucose level

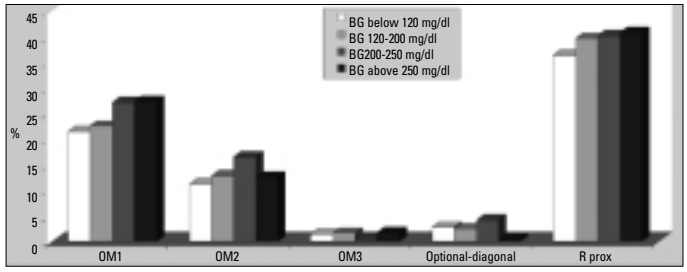


**Figure 2a. Atherosclerotic lesion distribution of first obtuse marginal artery (OM1), second obtuse marginal artery (OM2), third obtuse marginal artery (OM3), optional diagonal artery and proximal portion of right coronary artery (R prox) according to groups**

BG- blood glucose level

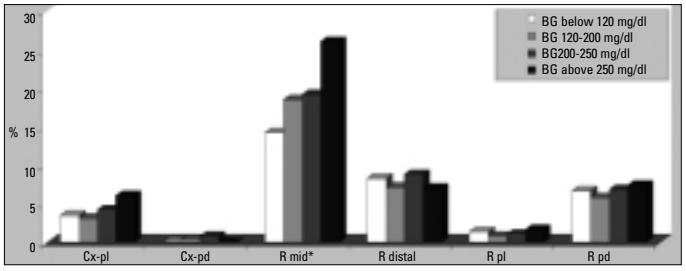


**Figure 2b. Atherosclerotic lesion distribution of posterolateral circumflex artery (Cx-pl), posterior descending circumflex artery (Cx-pd), middle portion of right coronary artery (R-mid), distal portion of right coronary artery (R-distal), posterolateral branch of right coronary artery (R pl), posterior descending branch of right coronary artery (R pd) according to groups (*- p<0.05, for differences between groups by ANOVA analysis)**

BG- blood glucose level

cardiopulmonary bypass were longer and their number of the vessels that had to be bypassed were higher (1). These results are consistent with our study. We found a significant increase in the incidence of female gender and multi-vessel disease, the duration of the operation, cardiopulmonary bypass and cross-clamp was longer in high blood glucose groups. But we found the incidence of hypertension to be high in low glucose groups. This may be because of the high incidence of male gender in low glucose groups. In our study, no statistically significant difference encountered regarding family history of CAD, the incidence of smoking, the type of angina pectoris among the groups.

Fish et al. (4) studied 200 patients who underwent CABG and reported that postoperative blood glucose level is predictive of complications and glucose levels >250 mg/dl, causes a 10-fold increase in risk of morbidity. Furthermore, 31% of these patients had clinically diagnosed DM and 21% of the study group had undiagnosed DM (4). In our study, approximately 40% of the patients in Groups 2-4 are found to have undiagnosed DM. The clinical diagnosis was established when they had applied to our hospital by the help of the routine tests.

An increase in morbidity and the length of hospital stay is another fact that has to be mentioned. A consensus on the effect of diabetes on the postoperative morbidity has not been yet reached according literature reports. Both Fietsam et al, and Kuan et al. found increased morbidities, related to the diabetes (19, 20). In the diabetic patients who underwent cardiopulmonary bypass, renal complications increased by 5 times, neurological complications increased by 3.5 times and their intensive care unit stay duration increased by 2 times (21). In our study, levels of urea and creatinine, though insignificantly, tended to be higher in the high blood glucose group. The CAD presentation with complications was more frequent in high blood glucose groups. Also, postoperative inotropic drug requirement and necessity for mechanical support with IABP was significantly higher in patients with higher blood glucose levels. Estrada et al (22) reported that, every increase in blood glucose levels by 50 mg/dl, increased the hospitalization period by 0.76 days. We found similar results supporting this study: the duration of operation, cardiopulmonary bypass and cross-clamp and hospitalization period were found to be longer in the high blood glucose level groups. The hospitalization period was 9.7 days in Group 4 and 8.1 days in Group 1.

In conclusion, diabetes mellitus and other risk factors have to be aggressively treated in patients who are planned to undergo CABG. The beneficial effects of the regulation of blood glucose levels on mortality and morbidity, both before and after the operation are valuable. High blood glucose levels were found to affect the preoperative variables in patients undergoing coronary artery bypass surgery such as increase in preoperative IABP requirement, emergent operation rate and the incidence of mechanical complications of CAD, intraoperative variables by prolonging the duration of cardiopulmonary bypass and aortic cross-clamp, increasing the requirement for inotropic support and IABP and the distribution of atherosclerosis of coronary arteries. These necessitate strict control of blood glucose levels in diabetic patients, which requires a multidisciplinary approach. Patients who have uncontrolled blood glucose levels or did not have clinical diagnosis of DM although they have high blood glucose levels should further be investigated. Investigating the patients for DM and controlling the blood glucose levels with effective protocols have to be accomplished to lessen the mortality and morbidity after CABG.

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